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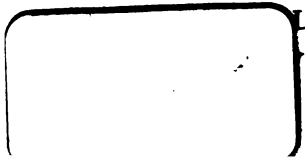


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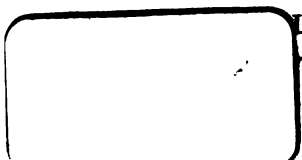


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Essential Points Governing the Financial Value of an Engineering Property.

An attempt to explain the influence of the engineer on the financial success of any of the following subjects, and written with the intention of making the relations of the engineer to the general public more definitely understood.

By

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NEW YORK

Printed by The Richardson Press

1912

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Introductory

THE first point to be made clear is to define the term "Engineering Property." By this is usually meant a large class of industrial properties that would require the services of an engineer in estimating their cost and in designing their arrangement. That would include water works, railroads, gas and electric light plants, water power companies, and projects of that kind.

It is evident that the first question which would naturally arise concerning an engineering property, is whether it will return a satisfactory income on the investment, as well as whether the original capital is there to stay or will eventually deteriorate in value. To determine this it is necessary to go through a certain line of reasoning and to make the proper deductions from that reasoning. The purpose of this book is not to go into any specific property, but is to show the line of reasoning to be used in each class of property in such a way that it can be understood by any one that is not an engineer and to be of assistance to him if he may be connected in any one of the following projects. It is not in-

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tended to be a technical work in the sense that it is instructive to engineers in their professional capacity. Instead it is intended to make clear the financial side of the subjects taken up, and to show the professional duties of an engineer which would have an influence on it.

It may seem as though few people would be interested in the properties mentioned below, but it is the purpose of this book to show conclusively that practically any one who is interested actively in business can find something of value in studying out these problems. A promoter would want to know the cost of a property as well as have a fair idea based on the records of similar work, or what the property in question is going to return to him financially. Similarly, an investor would not only be interested in the probable income, but would want to find out whether the bonds or stocks issued against the property under his consideration are backed by actual values of construction. The owner of any manufacturing plant is naturally interested in whether he will be able to cut down his expenses by adding equipment, such as conveying machinery, and the various kinds of loading and unloading devices. To the public at large, the value of a property as determined by an engineer is important in the fact that when municipal im-

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provements are considered, such as water power and the like, he practically pays through his taxes and assessments for the cost of this work, and any economy would be for his benefit.

An investigation to ascertain the first cost of an engineering project or to investigate the probable earnings would naturally apply to a small property as well as to a large one, and it is pertinent to say that no property, however small, should be carried out without the assistance of a member of the engineering profession. The tremendous scope covered by it makes it impossible for any one to cover the whole class of subjects covered by the profession, and requires him to specialize along certain lines which he may consider most interesting. This book, therefore, does not attempt to cover all branches of engineering. Some of which that are not included would be natural and artificial gas projects, roads and pavements, drainage systems for waste matter, canals, and problems dealing with the efficiency of management of industrial system. The class of properties considered here makes it necessary to take up surveying, tunneling and electric lighting, but only in their relation to the subjects as given and not as a separate and

distinct class of work as undertaken by some engineers.

In taking up the methods by which the financial value can be reached, it will be necessary to consider separately each class of property which this book will cover. This is due to the fact that not only will the parties interested be of different class, but the methods by which the value would be reached would be treated in a different manner and the results obtained would be considered from a different standpoint in each case.

One thing is in common in all of the following subjects. It is necessary for every engineer to fulfil through himself or his staff the duties of inspector. It is obvious that he must see that his designs are carried out according to his ideas, and that all his specifications are lived up to. In the subjects following, his specifications in regard to the quality of any materials which are to be used, are of the greatest importance. Through his knowledge of the physical properties of steel, concrete and earth, he can obtain the most economical results possible and yet insure absolute safety. The time to be allowed for any contract, and the manner in which it should be done, would also be embodied in any specifications. By restricting any builder to a specified method of

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erection he may ensure the completion of a contract on time, and do so before any contract has been consummated.

Any deductions in regard to the cost and future success of any of these enterprises would be obtained by comparing the results of properties similar to the one under consideration, taking into account any features which may differ. It follows then that the investigation of every property is a separate problem by itself with its deductions based on previous experience. It must be born in mind that the subjects taken up in the following chapters can be considered among the most conservative investments because of the fact that they have an actual property value behind them. This property and the usual franchises and rights that permit their operation, as obtained by the following methods of reasoning, guarantee their fundamental or capital value.

Water Supply

ANY community that is considering a water works system should take up first the question as to whether there is sufficient population within reach to warrant the necessary outlay. This is determined by taking a certain number of gallons per person as the probable supply required, making an allowance for future growth as determined by previous records which may be in possession of the census authorities. The next step is to have an estimate made of the first cost of this work and the amount necessary for maintenance. It is then possible to arrive at a definite conclusion as to its financial success by comparing the interest on first cost plus the maintenance, with the probable earnings.

The first cost may appear large but it must be remembered that in any system of this kind a continuous supply of water must be guaranteed, and the safety of any dams must be beyond question. To illustrate this point it is only necessary to call attention to the floods caused by broken dams and to the heavy fire loss due to interruption of water

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service. The first cost would seem to be increased by the fact that in order to insure this continuous supply it is necessary to have practically two complete plants, or to be more exact, two complete sets of everything liable to failure or requiring cleaning. This includes of course, pumps, reservoirs and pipe lines. The maintenance cost would vary considerably with the kind of system used, whether gravity or forced.

The gravity system should be used in every case in which the natural facilities are at hand. It will consist of a reservoir to catch and hold until used, the natural rain fall of the district, and the necessary pipe systems to connect the reservoir with the consumer. In order to use this system, however, it is necessary to have high ground within reach of the community in question. This high area must be large enough to gather a plentiful supply, and high enough so that water will flow from it by gravity into the top stories of the tallest buildings in the community below. This gravity system will be the least expensive to maintain, and when properly designed will be the most reliable.

The forced system is not all that could be desired, but is necessary in a great many cases on account of the fact that the community in question may be on higher ground than the

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surrounding country. In the forced system it is usual to drive wells and pump the supply directly from the wells into a reservoir, usually in the form of a steel stand pipe which acts not only as a reservoir, but as a governor to steady the water pressure. In this system it is absolutely essential to have two complete sets of pumps. They must be of a make both reliable and noted for their long continued action.

The geological nature of the land in which any proposed system of wells is to be driven is of the greatest importance and would be gone into by the engineer investigating a forced system of this kind. It does not always follow that the underground drainage will flow in the same direction as the surface drainage. The study of the geological formation of the strata underground will show the general inclination of these various strata and the probable area drained by them. It has the further advantage of showing whether the supply of water to be drawn off would come from a direction in which contamination may be expected, due to the presence of a drainage system of a nearby community.

One of the oldest forms of pumps which can be considered in a class by itself as it is entirely automatic, is a hydraulic water ram. Under

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proper conditions it would be considered as good as a gravity system.

The action of a ram can force a small proportion of the total amount of water obtained to a considerable height above the source of supply and do so entirely by automatic action. This system, however, can seldom be made on a large enough scale to be of use to any considerable community. It is most important in the water supply of small villages and to the owner of large industrial plants, and as such can be considered a profitable investment.

It often happens in water supply problems that the water in question will hold in suspension a considerable amount of earthy matter which will be in such fine particles that it will not settle to the bottom while in a reservoir. It must be understood that this sediment in no way impairs the value of it for drinking purposes if it can be filtered out. This is done by the construction of filter beds.

The latest type of filter bed is made of reinforced concrete. It consists of a reservoir divided into several compartments that can be separately operated. Along the bottom of these reservoirs are placed a number of covered drains on the top of which is placed first a coarse grade of sand, and then finer grades. The action of these filters is obtained by run-

ning water in at the top allowing it to percolate slowly through the sand, finally to be taken up by the drains and carried away in a clear state. The use of alum placed in solution in the unfiltered water has been found to assist this operation materially.

The sand, of course, collects all the sediment that was previously held in suspension and will become useless in a short time. At stated periods the top layer of sand must be removed, washed, and then replaced. This operation makes it necessary to have filter beds divided into separate compartments and additional filtration surface to make up for this cleaning.

When properly proportioned by the engineer in charge this method of getting rid of the matter held in suspension, is very efficient and the result will be a clear water. Filter beds will increase the first cost as well as the cost of maintenance of any system but will not necessarily bring these two costs high enough to make the financial outcome at all doubtful.

The most important duty of an engineer is in the selection of the kind of system to be used and in the proper designing of it. He would make use of every natural advantage found within the vicinity in which this system may happen to be. He should be assisted by the

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proper authorities in obtaining the necessary information as to population and data of a geological nature. The value of an engineer in determining the correct methods to be used in any system, can not be over estimated.

From the standpoint of the taxpayer it is not only a matter of economy but one of purity of water, safety and continuance of operation, and it is for him to realize that in any water system the strictest economy seldom proves the wisest course in the end. It is of interest to him as a probable consumer to see that the engineer in charge has had chemical tests made on the water to be used and that the result of those tests will give a soft water free from all injurious bacteria. It is of extreme importance to him to know that the derivation of this supply is away from the influence of the drainage system of nearby cities. Further, it is well for him to see that laws are enacted and what is more important, to see that they are enforced, which will prohibit any one from tampering with the reservoirs of the proposed system.

The investor, however, must necessarily look at any water proposition from the standpoint of an investment and not as a consumer. To this end he must know whether he will receive a reasonable income and be sure that his

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capital will not deteriorate. In regard to the deterioration of property, it can be said, that water supply companies are considered as being the most lasting of any class of securities.

It is obvious that water is not a luxury. It must be used every day whether in times of panic or not, and if once installed can be counted on as being permanent. In regard to the deterioration of this class of property, it is well to note that it is less than almost anything else, and can insure the investor that whatever was put into the property can be gotten out in the end, provided a small allowance has been made for renewals and maintenance. It is well to say here that gravity systems in particular do not require many renewals.

In relation to the cost of maintenance it can be said that it is usually a steady amount which can be counted on many years in the future, and that any fluctuation which may arise is generally due to future extensions which would be considered as a separate investment. It is pertinent to say that here again the gravity system is superior in economy over its alternative, the forced system which requires pumping. To arrive at a definite basis on which to base any calculations as to whether a water supply property is a good investment, it is best to find out definitely if the proper

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authorities have authorized the financial end of it. After that, the fact that the bonds represent actual value can be ascertained through an engineer who can place the value on the property.

The cost of maintenance and operation can be also valuated by him. Its probable earnings are much easier to estimate upon. Knowing the population which the system in question covers, it would be easy to derive the total amount of water to be consumed if the conservative allowance per capita of eighty gallons per day be used. This total quantity of water, when reduced by the usual water rate in force in that part of the country, will give a probable income which is more certain than almost any other estimated income. As a class, water supply companies will give to the investor a sure income and an actual value behind the capital it represents.

Electric and Steam Railroads

IN THIS discussion of railroads only new systems will be considered. Railroads which have been in operation for any length of time can show their earnings and general ability to prove their worth from previous records. On the other hand, a new location has to be studied as a separate problem, and should be done by an engineer. It should be emphasized that the duties of an engineer in the first location of a railroad system, whether it taps new or thickly populated country, is of the greatest importance. In showing the relation of an engineer to the public, it would be pertinent to give some idea of what he can accomplish by making use of every natural feature which may come to his attention.

In the first place the primary cause for building a railroad is to connect two important places. In general there are several different routes which will connect any two points. The choice of the final route is usually governed by the topographical nature of the country. The topographical features of a certain district might be explained by saying that rivers,

mountains, or any rise or fall of the surface of the country would be considered as a topographical feature. That is topography is the condition of the surface as left by nature.

It is obvious that it would be more economical to construct a railroad which would require the least amount of grading and the fewest streams to bridge. The effect of choice of route is most noticeable when going through a mountainous country.

In locating a railroad the engineer cannot always pick out the most economical route because in so doing he may not touch important points that should be on the future system. It is for him to decide whether the extra cost in reaching this point would be made up by the revenue derived from it. For instance, a town may be situated on the opposite bank of the river from which the location would naturally be laid out and would, therefore, require a bridge to enter the town and probably one to leave it. To estimate as to whether this would be worth while, it would be necessary to find the cost of the bridges in question and compare the interest on that cost with the probable income derived from it.

It oftens happens that instead of a stream to encounter, a city may be situated so high from the rest of the line that it would require

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considerable grades to reach it. In this way it is evident that it is not always profitable to reach every town on a line and that any system should not necessarily be condemned simply because it does not tap everything within apparent reach.

The customary method of speaking of grades is in percentages. That is, when a one per cent. grade is spoken of it would mean a rise from the horizontal of one foot vertically while going through a distance of one hundred feet. The effect of grades on traffic can best be shown by stating that an engine can only pull one-third of the freight up a one per cent. grade that it can on a level track. And of course any increase of grade will decrease the amount of traffic that can be carried by any one engine.

The question of grades has a very important effect on the future maintenance of any proposed system. It is the duty of a locating engineer to strike a just balance between the interest on the first cost of reducing grades, and the saving in maintenance due to this reduction. In branch lines, in which traffic will not be of a heavy character like coal or ore, it will be found that the most economical method will be to permit heavy grades and save on the first cost.

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A heavy trunk line will find itself extremely inconvenienced and its maintenance cost running too high if it is not laid out with due regard to the proper grades and their influence on future maintenance. This only emphasizes the fact that the success or failure of a proposed railroad system is dependent largely on the ability of the locating engineer. Another item which enters strongly into the maintenance cost and the general efficiency of any system is the road bed itself. By that is meant the rails, the ties on which they lay, and finally the actual ground itself. The size of rails to be used is always governed by the traffic expected to run over them. A railroad that has considerable grades may find it best to use heavy engines which will make it necessary to lay the system throughout with heavy rails. Vice versa, light traffic will accomplish great economy in first cost.

The ties upon which the rails rest must be chosen in accordance with the traffic used. That is, large ties for heavy traffic and small ties spaced further apart for light traffic. In any permanent road where the cost of timber is high it may prove profitable to put these ties through one of the many preserving processes.

Drainage is the most important point about

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the actual condition of the road bed itself. Good drainage should be obtained no matter whether the proposed system is permanent or temporary, as it is practically the foundation upon which the whole operating equipment moves. No locating engineer would permit a saving in expense at the cost of a probable future washout.

In general the choice between the power used, either steam or electricity, is made on account of the haulage expected. Steam is in use for long hauls where speed would be required, while electricity at the present time is used on most slow speed lines and where freight or passengers would be expected to travel only a short distance. The cost of installing the proper apparatus for a long distance electric railroad is considerably above that of a steam railroad. This extra cost is occasioned by laying a third rail and the necessary transmission systems to get the electric power to that third rail when at a distance from the source of current. Steam, therefore, is the motive power for practically all long distance railroads in which each piece of freight can be expected to cover a long haul.

Electricity is always favored for urban traffic, not only on account of its cleanliness, but on account of the fact that it is more econom-

ical than steam when a greater number of transportation units are moved over a short line. An investigation of power consumption seems to show that electricity for transportation purposes in urban traffic is more economical than steam.

While speaking of power it is well to note a comparatively new system which has shown evidences of having a good future before it. This method is to generate electricity by a gasolene motor, which is mounted upon a car making an independent power generating plant. For branch lines extending from a trunk railway this will probably prove to be a considerable factor in reducing maintenance cost.

In special cases it may prove expedient to make use of hydraulic power and convert the same into electricity for the use of transit systems. The subject of hydraulic power will be taken up later under its own classification and will not be considered here.

It often proves advisable to tunnel through a mountain instead of going around it or climbing up to its top gradually by the use of a long grade. Tunnels as a rule should be avoided, especially on new lines, as they tend to increase the first cost. They prove advantageous, however, in reducing grades on established systems and can be bored with per-

fect accuracy. They are, however, an expensive addition to the road bed and should be avoided if possible. In constructing a tunnel an engineer will attempt to drill it at as many places as possible in order to save time. The customary idea that tunneling is a problematical experiment based entirely on guess work is erroneous. Any engineer accustomed to that work can estimate its cost very closely and can be certain of carrying it through successfully.

Bridges enter into the construction of a railroad and have an important effect on its cost. The methods by which an engineer would take up a structure of this kind will be fully explained later.

An investor who is considering entering into the financial end of any proposed railroad should take up first of all the question of what does this railroad connect. In other words, is the city at each end of the line attractive enough to make this road a success.

He must remember that a proposed line often connects a large city with a trunk line or with a terminal, and in that event he can leave out of his consideration the population at the end where the connection to the original system is to be made. Instead he should take up the traffic that exists on the line connected, and consider its effect on his proposed system.

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If the line is long and goes through fertile and thinly populated country, it can be assumed that after a few years that country will be paying its share for freight.

It must be born in mind that a railroad tends to build up its surroundings, which in turn increases the value of the railroad itself, and that slow growth based on conservative operation will eventually be the best.

It is not advisable to invest in any system that is operated through a country that has undergone too fast a growth. A mushroom growth is generally followed by an equally quick shrinkage. The fundamental idea in investing in any railroad system is to have real worth behind it. This will be shown in its earnings if the system passes through fertile soil and large cities, or connects other transit systems that have been established and have proven their worth.

In other words, the fundamental basis on which all railroad property should be based is that of stability caused by actual manufacturing industries of a staple character, or by the actual proof that the land traversed is capable of growing good crops. Of course it is not necessary that a proposed system should pass through this district, but if not, it should be a connecting link between districts of that nature.

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To insure the capital invested it is necessary to see that the financiers have received their franchises and rights from the proper authorities. Overcapitalization can be guarded against by seeing that the engineer's estimate of original cost has not been exceeded except by that due to maintenance for the first few years.

The above suggestions would apply, of course, to a promotor who would wish to see his securities on the market and give good results to his customers. A promotor can apply the engineer's estimate of the first cost and his own knowledge of the territory traversed and from that reach a definite conclusion as to the financial worth of his system. The public in general should realize that for every dollar saved by an engineer they will evidently benefit to some extent through the reduction of freight charges and passenger rates.

Competition is an important point to consider in investing in a new railroad system. The customary idea that competition is ruinous to the success of a new railroad is very often wrong. If it can be proved that the new system under consideration has a road bed which can be operated more economically than its competitor, and that will get equal rights to operate, it will turn out to be an advantage instead of a detriment. It will not be neces-

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sary in this case to enter an entirely new territory and build up its own trade, but will instead outdo its old competitor by virtue of its better location and more economical operation.

There is one class of railroad that may be considered profitably, though not coming under the head of a railroad as understood by the public at large. Many mines and large industrial plants find it to their advantage to add small transportation equipments of their own. A railroad of this kind can be made profitable on any long haul in which the freight to be carried consists of large, bulky material, such as ore and coal.

It has the advantage over other railroads that its income derived from transportation is a known factor and established by the company which operates it. That is, an ore property operating its own system would know definitely how much material it would carry, as well as the distance over which it would be hauled.

The cost of maintenance and the first cost would be derived by an engineer in the same manner in which he would obtain them in a public railway system. He may, however, be assisted by the fact that he could use a narrow gauge for his rails and save in road bed expenses.

Hydraulic Power Systems

THERE are two ways of classifying hydraulic power plants in regard to their purpose. The first is one in which a company is already formed and has been using as its prime mover either steam or some other form of energy. This company would look at water power purely as a matter of economy and the question of a market for its power would be settled. That is, a hydraulic plant would be considered only as a cheaper method of obtaining energy.

For instance, it often happens that a company has been formed and has been in operation for some time, which will manufacture a certain sort of product. It may be brought to the attention of the owner at some later date that within a few miles of the site of his industrial plant is located a source of water supply, probably in the form of some stream which may have a waterfall or rapids somewhere on its course. If it should be a mill in which the water wheel can be directly connected to the machinery, or if it has to be transformed into electrical energy and sent

through a transmission line to the manufacturing plant, is a question that must be decided by the engineer who is designing and estimating on this work. The owner must take into account the fact that in order to be economical the operating cost of his water plant must not only be cheaper than the operating cost, including the price of the coal in a steam plant, but the sum of that operating cost and the interest on the cost of installation of the water power must be less than that of steam.

This is decided by the topographical features of the country in relation to its water supply and the price of coal at that locality. It is a common thing for paper mills, saw mills, and flour mills, or, in fact, any other mill requiring power that may be located in the country, to be run by hydraulic power. In showing the relation of an engineer to the public, and in bringing out the facts which govern the financial value of a hydraulic plant, it would be best to give some of the reasons which would influence him in his decision.

The most economical method of operation is to run the machinery directly from the water wheel itself instead of transforming the mechanical power derived from water into elec-

trical energy, transporting it a short distance and converting it again into mechanical power.

In a direct connected system it is necessary to have the water wheels or turbines within a short distance of the machinery to be run. It must be understood that this distance referred to means not only a short distance on the level, but must be within a small distance vertically. Unfortunately it is seldom possible to put a power using mill in the bottom of a narrow valley where the actual turbines would be ordinarily placed. Whenever this is possible, however, it would be used instead of electricity. The actual connection between the water wheels and the machinery in an industrial plant would be made in this case by shafting, and any reduction of speed, due to the fact that the most efficient speed of that water wheel may be different from that of the machinery, would be made through reduction gears. The engineer in charge would, of course, make his decision whether direct connection would be advantageous, by considering each project as a separate study.

It will be pertinent to say that almost any quantity of water power can be used. If the quantity at hand is too small to run the machinery required, it can be stored in a reservoir similar to the reservoirs used in water

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supply for cities, and the quantity stored can be used in intermittent periods in which the full power can be obtained.

The second case to consider is one in which the purpose of the hydraulic plant is to sell the power generated to different customers instead of as in the first case, erecting this power plant for the sole purpose of furnishing power for the owner's benefit. It is obvious that a direct connected hydraulic plant cannot be used when the power consumed will be taken up by many different customers.

The distance from source of supply to consumer is a large factor in establishing the financial future of any hydraulic company. It has been found by practice that there is a loss of energy in transmission lines which carry electricity over any great distance. Also the first cost of the line makes it prohibitive for any but the largest companies to carry their power over any considerable distance.

It would be well in a company of this second class to look carefully into the question of the sale of power and to make sure that there is sufficient market to consume all the power generated. Within a short distance, which will depend of course on the size of plant erected, should be a large enough community to consume all this power. It is best in this case

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to take a community which will take away an even supply of energy, and in doing so cut down what is known as the peak load. By a peak load is meant an extra load which would occur at a certain time in the day. That is generally about 5:30 o'clock in the ordinary city, when factories and offices are lighting up and when traffic undergoes its rush hour, and in addition, residences will require lights. In general any power plant that has for its consumers those who will consume steady power, can be considered as a good business project. As an example of this steady consumption of current, it could be said that any power plant devoting its energy to a number of manufacturing industries which are more or less constant and which keep steady hours of operation, are bound to show themselves to be a profitable class of consumers. It is seldom possible, however, to have consumers so placed that a sudden increase of power used can be avoided. It will be the duty of the engineer, therefore, to use his knowledge in forming some method of distributing his machinery so this sudden increase of power can be taken care of, and without adding any extra amount of machinery.

The most difficult question to the engineer is in the design of dams. It is of the most

importance to design a dam that is safe. The loss of property caused by sudden floods, and the possible loss of life makes necessary the most careful attention of any engineer. The purpose of a dam is either to back water up to the level required, or to act as a reservoir to retain a sufficient quantity to keep the hydraulic plant going in time of a drought. If the case of a large slow-moving river be considered, it can be readily seen that a dam stretched across it will back up the water behind it until it reaches the top of the dam and this dam would be considered as one serving only as a wall to back the water up to the required level. It often happens, though, that a stream high up in the mountains will run dry in the Fall and will be full of water in the Spring. An engineer in designing a dam for this case would design it primarily in relation to its purpose as the closing wall of a reservoir. To be sure, it may act similarly to the first case, but its primary object will be to store up sufficient water to last over periods of dry weather. An engineer accustomed to this class of work would pay his strictest attention to the foundation upon which the dam sets, and would personally see that his directions were carried out. The kind of dam used, whether a concrete, steel, or an earth embank-

ment, is one to be decided upon when the different natural conditions have been carefully looked into.

It may be of interest to know that no matter what kind of a dam is built it is always advisable to have in it what is called a spillway. A spillway is a wall, the top of which is lower than the top of the dam. If the water rises too high, as it would in times of extremely wet weather, it will flow over this spillway and away from the dam. This method of getting rid of a sudden rise of water prevents any injurious action to a dam by directing the waste into channels which are made especially for that purpose.

The question of the amount of energy or power to be derived from any stream or water shed can only be decided by an engineer. It may be of service to others, however, to have a general idea of what his duties would be in this case. In the first place he would be expected to collect all data available in reference to the rain fall of that region and to note carefully the length of periods of drought that occurred in the past. He must then visit the site of the proposed plant and make careful surveys. These surveys would include all the topographical features encountered and as much data as possible of a geological nature.

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Further, this survey must include a series of stream discharge measurements covering a reasonable length of time. That is, he must not only know how much water is flowing through that stream, but he must have a reasonable knowledge of the average quantity of water which that stream is capable of discharging over a long period. In addition to that it is absolutely necessary to have careful systems of levels run along the banks of the stream in order to find out how much available head he will be able to obtain. The available head of a hydraulic plant is the difference in height between the point where the water is taken from, and from the point where the actual turbines, or water wheels from which the power is derived, are located. The actual amount of energy that is possible to be derived from any one power plant is dependent chiefly on the amount of water available and on this so-called head.

An engineer can calculate the amount of power to be obtained in any case and can design and estimate the first cost and cost of maintenance on any water system. In his estimate and design of a system it is part of his work to see that the kind of power machinery is used that will give the most efficient results consistent with the conditions which

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meet him. That is, if he can obtain a high head or a low available head of water, he must design the water wheels in proportion, and in doing so obtain the greatest amount of energy possible to be derived from the amount of water that can be obtained.

It has been found best to use a form of water wheel, known as an undershot wheel, wherever the actual fall of the water is under four or five feet. It may be interesting to note that this is the original kind of water wheel used when water power was first in use. From available heads of five feet to four or five hundred, turbines have been found to be the most efficient. They would be designed, however, especially for the available head to be used in each case, and it should be remembered that they are not bought and sold like merchandise, but are subject to the design of an engineer. Any height of water over this makes it necessary to use a new type of wheel known as an impulse wheel. Its power is derived entirely from the striking force of the water instead of its weight. It is possible for an engineer to foretell with accuracy whether the proposed company will be a success financially as far as the amount of power and the cost of it is concerned.

Its market is either governed by an indi-

vidual as in the first case mentioned at the start of this article, or is sold to a community. In the latter case the promotor and financiers would be the ones to decide whether the amount of available energy could be disposed of at a profit.

To an investor considering a water power problem four points are of the greatest importance. The first one is the quantity of power to be derived and actually found at the point of consumption, which is, of course a matter to be decided by an engineer. The second point is the fact that the bonds represent actual values put in construction. The third point is the question of water rights. It should be known that the proper authorities have authorized and given their consent to the water rights of any proposed power plant. The fourth point, market, is decided mostly by that rare quality known as common sense. By this is meant the ability to know that after having generated a certain quantity of power, that it is possible to sell that power at a profitable rate. The interest on the first cost added to the maintenance cost, as derived by the engineer in charge, will give the expenses to be expected by any company. The probable income would be the total quantity of energy derived, taking into account the rates favored

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by competitors that may be operating in that vicinity. As has been said before, the question of the competitor's prices for power, and of finding a suitable market, would not interest the owner of an industrial plant, as he would probably undertake this proposition for the sole purpose of effecting an economy in an industrial plant already erected.

Hydraulic power companies have the advantage as an investment that the original capital is represented by an actual property of intrinsic worth. The water rights, franchises, machinery and other equipment, all represent a value that would not deteriorate in the future. If the consumption of the power generated has been established, it will be found that the fundamental value behind the capital will increase in value. This increase is due to the fact that a reduction of power cost in any vicinity will tend to increase industry.

Drainage of Lands Partly Inundated

THE first question that would rise in a drainage problem, the nature of which is to drain water from a marsh and to make it productive, is to note whether there is an outlet for the water that is to be drained off. In almost every case a marsh or partly inundated stretch of land will be situated near a water course in such a way that this question of outlet will not be serious. It must be borne in mind, however, that, in certain cases such as in sink holes which occur in Florida, these marshes will not be so situated, and then the question of outlet must be carefully considered. Therefore, the drainage of the usual type of marsh, that is, a marsh situated near a river or lake, can generally be made a successful and profit-paying improvement.

The actual methods of drainage itself can be divided into two classes. The most common and advantageous one is that in which natural drainage will carry away the flow of water by gravity. The second case is one in which pumps are used to pump this water

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away and is financially successful only in large areas and in special cases. The drainage of Holland was accomplished almost wholly by this second method. It is obvious that any system which drains land solely by the natural flow of water costs less to maintain than one in which that flow must be assisted by the action of pumps. In a pumping system there is not only the first cost of the pumps and their installation, but the cost of maintaining them at their proper state of efficiency. The cost of maintenance would consist of the fuel and the lubricating oils used, and finally the cost of the men themselves who operate these pumps. In small plants the fuel used may profitably be gasolene, and in some special cases gasolene or steam could be assisted by wind mills. The latter, however, should not be counted on to do the work alone, as they are unreliable in times of excessive rainfall, when the pumps would be required immediately. It is obvious that the salaries of men employed in operating the pumps would be less in gasolene than in steam. This whole cost of maintenance becomes less and less per acre as the size of the area to be improved is increased. That is, a large area can maintain a pumping outfit at a comparatively small cost per acre.

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On the other hand, the maintenance of a gravity system is practically nothing with the exception of occasional repairing of ditches and dikes. It is possible for a drainage engineer to economize in his design and arrangement of a system. He is able through his knowledge of waterflow and seepage through soils of different nature, to obtain the utmost efficiency out of the size and location of the drains which he lays out.

Up to the present date there are two general systems in use. The open system is composed of open drains traversing the field in question in such a manner that the maximum amount of water will be carried away with the least amount of expense in digging these ditches. The other system has for its drain, pipes, generally of vitrified clay, which are laid down a few feet beneath the surface and are then covered up. Any water held in suspension by the soil above gradually enters the joints between the ends of the pipe and is then carried away to the outlet. This latter system is more expensive than the first, but has the advantage that the top soil is left undisturbed for cultivation. In general the aim of the engineer in laying out drains is to form them in straight lines perpendicular to the natural flow of the water, in nearly every case this will

result in a gridiron effect in which the various branches will end into a main drain, which in itself will carry the water into the outlet.

The area that can be made useful by proper draining is greater than would be supposed. Almost every river or lake of any size has at its edge big areas of land which can be improved and raised from a condition of uselessness to one of equality with the best farm lands surrounding. Lakes and streams located in flat countries are specially liable to have a big percentage of the acreage surrounding them in the form of a marsh. In general a farm which has the advantage of a pond or water frontage on a river, will also have the disadvantage of a considerable amount of useless land included in its area.

Part of these marshes can be readily reclaimed and made useful by the simple method of building a dike or embankment of earth between the water course in question and the marsh. If possible a channel could then be dug from the marsh itself to a point down stream which would then permit drainage by the natural flow of water. To explain this further, it should be borne in mind that the part of the water course immediately adjacent to the marsh under consideration would be at the same level as the water in the marsh itself.

But every stream tends to flow down hill, and therefore, if it is possible to connect the marsh by a separate channel to that point down stream, and in the meantime protect it by an embankment from the water in the stream near it, it will prove a convenient method of drying the land in question without the use of pumps. If this is not possible, direct pumping would have to be resorted to and could be made profitable on a large enough area.

The usual condition for hilly country through which a stream passes, is that the part of the slope of the hills nearest the stream is in a perpetually wet state. Drainage from the hills in that vicinity sometimes have the effect of making a marsh of the land adjacent to the water course, although it may be a few feet above water. A case of this kind is the least difficult of all to drain. The fact that the land in question is located above the natural water level for that vicinity makes it possible to use the natural flow of the water itself in drying the land so that it may be made productive. The productivity here is made sure by the fact that the roots of all plants, except the largest trees, will be above the natural level of the water held in that stream and will, therefore, be unharmed by too much moisture.

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Land of this kind cannot be subject to floods if properly drained.

Florida and a great many Southern states that are not mountainous have marshes without any apparent outlet. They are sometimes dry part of the year but seldom dry enough for cultivation. A considerable amount of this waste land can be saved by applying the proper methods suitable to each case. If possible a drain would be dug from one of these sink holes to a stream or outlet nearby and would in this way obtain good results without any mechanical assistance. If this is not possible a pipe line would extend from the lowest point in that marsh to the nearest outlet in that vicinity and drainage would be obtained by pumping. Drains radiating from the lowest point in the marsh would serve to collect the water and bring it to the pumps. One point will always be taken into account and that is to provide a sufficient reservoir by excavation if necessary at that point of lowest depression in order to provide for any sudden rainfall. The water collected can then be pumped out slowly and the danger of flooding avoided.

It must be borne in mind that an engineer would always attempt to use the gravity system where the natural conditions would allow.

The forced system, however, can be made profitable when the area to be drained is large, and where the outlet is not at too great a distance. The land uncovered after a sink hole has been drained, is at least as good as the surrounding land and can usually be counted upon to raise better crops, due to the fact that the water held in suspension seems to collect fertilizing elements.

An engineer accustomed to drainage work can pick out the best method that will accomplish the result required by making use of all natural facilities at hand. He can obtain, both in the methods employed and in seeing that his method and ideas are properly carried out, the strictest economy for the benefit of those interested in any improvement of this nature, and in that way assist in making it a financial success.

The financial end of an improvement of this kind would be of interest to two classes of people. It often happens that a company will be formed by men of means to buy a large acreage of marshland with the intention of improving it by the use of drainage and then sell the land improved at prices under which farm lands in that vicinity are usually sold. A financial venture of this kind can be made a profitable one entailing a minimum amount of risk.

The first thing that anyone interested in such a company must take up, is whether the title for the land in question is good, both before improvements and after the nature of the land has been changed. The question of title of lands under water that border on a navigable stream, is one that should be carefully considered. The simple fact that it borders on the property of the company or individual installing an improvement of this nature will not necessarily establish the ownership of any land that may be reclaimed from under water.

It is of the greatest importance to know that after having made these improvements that the resulting property can be used for the purpose of growing crops. Any land that is not composed of stony ground, and which is not under the influence of salt water, can be made to produce the usual crops found in that vicinity. Fortunately it is possible for a prospective buyer to tell whether any particular land can be made productive by seeing it and noting whether it has the same consistency as that surrounding it. The amount grown per acre on improved lands is practically always greater than that grown near at hand. This seems to be due to the fact that it collects by virtue of the extra amount of water held in suspension

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the various elements which tend to make the soil productive. The old bed of marsh, which has had time to thoroughly dry out, would support a more luxuriant growth than anywhere in the immediate vicinity.

A company that has the proper title to the property, and the knowledge that the property after being drained can be made productive, has next to go into the question as to whether the proper authorities will permit the improvements under consideration. This point should be carefully looked into, as it is fully as important as the title itself.

The financial status of a company undertaking this class of work, would be seriously affected through the selling end if the property under improvement is not situated so that the produce grown upon it can be easily transported to the nearest market. Good transportation as used for farm produce consists usually of good roads leading to the point of production, and a railroad or boat line a few miles away, which in turn leads directly to the market. It cannot be expected, of course, that agricultural property can be so located that its produce can be loaded into a railroad or boat without the use of wagons.

To any one interested in a company of this nature it is well to note that the cost of the

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land as bought unimproved, plus the cost of improvements as estimated by the engineer in charge, is well under the usual price paid for good farm lands in that vicinity. In other words, it is necessary to know that the engineer's estimate of improvement cost is enough under the increased value of the land as improved to give a good profit.

A land owner in considering an improvement of this nature, should consider whether he has obtained the right authority to improve his property if any would be required. It is of the greatest importance to him to know before expending any sum on it, whether he can make use of the property in question and drain it into good farm land. As was mentioned before, any land out of the influence of salt water, and not of stony nature, can be considered a good proposition. He will know from his past experience how much he can obtain per acre as a profit on the rest of his property, and by using the cost of improvement as estimated by the engineer, can easily find whether the property in question will be a financial success to him. For example, the interest on the first cost added to the amount necessary to keep the system in good order, can be considered a yearly expense item. If the profit derived by the owner on an area

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equivalent to the one improved, is greater than this yearly cost, he can be satisfied that his improvement will be a financial success. It can be borne in mind that land of this kind can be safely counted on to produce larger crops than that which has been under cultivation for any length of time.

Irrigation of Arid Lands

THE primary object in an irrigation system is to buy land at rates consistent with the fact that it is arid, to improve it by watering and to finally sell or cultivate the property irrigated at a profit above the cost of the improvements themselves. In selling property resulting from the operation of an irrigating project it is necessary to guarantee to the future owners a permanent supply of water. That is, while the land itself can be sold outright the continuous operation of the water system itself must be counted upon. The general methods are either to sell the water at a guaranteed rate inserted in the bill of sale for the land, or to make up for the cost of maintenance and operation by assessing the land at so much per acre.

There is a considerable amount of land in the Western part of the United States that at the present is practically useless and which can be bought at an exceptionally low price. Records seem to show that the total amount of acreage irrigated in 1910 is 19,300,000, which has been improved by a total cost of \$304,700,000. These figures compare very favor-

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ably with the total of 7,500,000 acres irrigated at the end of 1899 in showing the tremendous increase in this class of improvement. These figures show that the first cost per acre of installing an improvement of this nature is not excessive. The cost of operation and maintenance for a year has been given as \$1.07 per acre, which is considerably under the usual profit derived from farming operations. If it should happen that arid lands are so situated that they can be irrigated, it would prove profitable to buy them and then sell them after the improvement in question had been done. It is necessary in order to irrigate any land successfully, to have a sufficient water shed near at hand and at a higher level if possible than the property to be improved.

In considering the quantity of water needed to irrigate any stretch of land, it is necessary to know the crops raised in that region and which may be expected to be grown there when improved. When this is decided upon it can be definitely known how much water will be required for any certain kind of produce. Suppose, for instance, that a certain property was located in a region which would be suitable for fruit growing, and especially for apples. In that case the amount of water required for that particular crop would be

carefully considered and would be used as the amount needed to successfully carry through that irrigation. It must be borne in mind that considerable surplus would be required by an engineer in order to make allowance for the production of many other crops that may be suitable for that climate. The engineer in charge would make a careful survey of the water shed from which this water is obtained and find out whether this required amount can be obtained. This survey must of course, take into account long periods of time.

The rain fall is of the greatest importance in showing whether there is any likelihood of having long sustained drought on the water shed in question. The effect of a drought on any land would mean the positive failure of any crops and a considerable loss to the owners. It is very important then that the past records of the water shed, from which this supply of water is to be taken, should be carefully noted. It can generally be assumed that if no droughts have occurred in the last five or six years that there will be none in the future. Almost any stream, however, has an annual variation of flow which may be sufficient to cause serious inconvenience. That is, a stream running through a mountainous country, and through regions accustomed to snow

in the Winter time, will usually have a heavy discharge in the Spring and a light one during the late Summer.

Under conditions in which the supply of water is varied to such an extent that it may cause temporary drought, it will prove expedient for the engineer to design a dam that will impound a sufficient quantity to guarantee a continuous supply of water. That is, if he should build a dam across a stream he will cause the water in that stream to form into a lake, the size of which depends on the topographical nature of the country. This lake will act as a reservoir from which the water can be drawn at will. It is pertinent to add that a sufficient surplus of water would be on hand to make up for the loss by evaporation, and that through seepage at the bottom of the ditches and reservoir.

At present there are two systems of transmission to carry water from the reservoir to the land to be irrigated, which are open to the choice of the engineer in charge. The system of open ditches is, of course, the least expensive one to follow. It requires, however, ideal conditions in which the reservoir must be practically at the same level as the land to be improved, and furthermore, the country between them should be nearly at that level. This

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would make an inexpensive system and one which is more efficient than a pipe system. The use of pipes would be necessary where the water would cross a valley or run over a ridge of hills too wide to permit economical tunneling or bridging. In a case of this kind the line laid would be away from the natural level which would be taken by the water if permitted to flow freely. A pipe line of this kind would be called a siphon.

The other method of carrying water over a valley is, of course, by building a viaduct or bridge, so that it may flow freely through a pipe or open trough placed on the top of this bridge. When passing a hill which is very high and narrow at the bottom, it may prove more economical to tunnel through it than to build a pipe line over the top. In the siphon mentioned before, as a method of going over a hill or along the bottom of a depression, it is not necessary to use pumps if the outlet end of the pipe is lower than the end near the reservoir. This is due to the fact that water will tend to flow down hill, and if in a closed pipe with one end lower than the other, it will actually flow up hill a short distance and then down hill on the other side a greater distance, in this way making its total flow in a down hill direction.

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The customary method at present of spreading water over the land to be improved, is by using open ditches. They are arranged in a gridiron formation and are spaced according to the amount of water required per acre on the land to be irrigated. The main branch of these ditches will lead directly from the line which comes from the reservoir, and will in turn empty into various branches which act as distributors. The actual distribution is assisted by the fact that any soil will tend to absorb water, and in doing so will spread it uniformly between the ditches.

The design of any system of irrigation as done by an engineer, can be considered of the greatest importance. By the proper layout of his work he can create the greatest economy consistent with the successful carrying out of the enterprise. He can also foretell with accuracy the amount of water to be obtained from any water shed as well as the loss in transmission from the point of supply to the land to be improved. He would investigate the question of drought in its influence on the future productive value there. The question of whether a reservoir is necessary or not must be decided by him, and in doing so he will be able to guarantee a continuous supply of water. Through his knowledge of costs of construction he is

able to decide whether it will be better to use the siphons mentioned before in this article, or whether to tunnel or bridge in overcoming the natural difficulties in transmission.

The financial end of an irrigation system, in which land is bought at a low value and improved in order to be sold at a considerable increase, would interest the promotor and the investor as far as the financial outcome is concerned, and the buyer as far as the future productivity of the land in question.

In an improvement of this kind it is necessary to know that the water rights have been given by the right authorities. Further, they should have been drawn up so that they cover the right to draw away water from the water shed in question, to transmit the water to the place where it is used, and finally to make use of that water in the property to be improved. The title of the irrigated land is of interest to all parties concerned and must be to the satisfaction of any legal authority liable to investigate it in the future. A prospective buyer should pay the greatest attention to the water contract which is given with his land title. He should see that he is getting water at a reasonable price and must be careful to note that that rate will be a permanent one and stated as such in his deed of sale. If the method of

payment for water is in the nature of an assessment it would be advantageous for him to know whether he will obtain a vote on any committee which would fix assessment rates. In any case he should guard against any raise in the cost of his water in the future.

It is of interest to an investor, placing his money on a project of this kind, to know that the stocks or bonds issued do not exceed the cost of the land plus the engineer's estimate of the cost of improvement. A slight addition to this, however, is necessary in order to cover carrying charges for selling property and various other incidentals not included in the engineering side.

Transportation facilities near at hand are of the utmost importance in determining the selling value of this property. In lands intended for farming, good transportation consists generally of good roads in the immediate vicinity and a railroad or boat line a few miles away which will lead directly to a large market. It is not necessary to have a railroad in the immediate vicinity as it is generally understood that farm produce would be loaded into wagons and by them driven to the nearest station and there loaded into cars. In order to do this, however, good roads having minimum grades are essential.

All parties interested are also governed by the nature of the land itself. That is, it is not always true that land will grow farm produce just because it is watered. It is true, however, that practically any land that is not too full of stones to cultivate, or is not formed entirely of sand, can be made to grow crops according to the latitude and climate in which the property is situated. Those interested in a matter of this kind should be cautioned to look out for soils of an unusual nature which may contain mineral elements detrimental to the growth of plants, such as too much salt.

An improvement of this kind has an advantage that may not be necessarily considered as a financial gain, but should influence any parties interested. They will have the satisfaction of knowing that a system of this kind is one of actual improvement. That is, it takes up useless land and transforms it into a permanent and productive part of the surrounding country which will add to the general value of all transportation and industrial projects in that vicinity.

Bridges and Viaducts

BRIDGES and viaducts are terms which are very often misapplied. A viaduct is generally considered as a kind of bridge which is unusually long and composed of a great number of spans, each span being considered as that part of a bridge between any two piers. In addition, any bridge of any length for the purpose of carrying street traffic or an aqueduct for water, and which may have some claim to architectural beauty, would be considered as a viaduct. In general the term viaduct is accepted as meaning a bridge which can be considered a feat in architecture. This meaning has since been broadened to include a structure of any great length and composed of a number of small bridges or spans as was stated before. This would leave to be classed as a bridge the various kinds of railroad and highway structures of medium size which have been erected solely for a commercial use and having very little attention paid to its architectural side.

Bridges and viaducts can be divided into three classes according to the kind of material

used in their construction. These classes are steel, reinforced concrete, and timber bridges. In the discussion following, the word bridge will be used to include both bridges and viaducts in their various forms. The judgment of an engineer is important, first of all in the choice of materials used, secondly in the choice of form in which the bridge will be built, and finally in the economical design of the bridge that will be finally constructed.

The various forms in use at present and which are subject to the choice of the engineer in his design, are suspension, lift or swing bridges, cantilever, arch, and what is known as a simple bridge. The distinctive points governing the various forms stated above, would be helpful in assisting any one to understand how the judgment of an engineer guides him in his choice of type to be used. The suspension bridge has two uprights which are usually called towers, from which are suspended cables or chains that in turn hold up the bridge. In other words, the word suspension itself explains the method of support used in this type. The cantilever system is based on the principal of a rigid arm held so firmly at one end that it will support the required load resting on the outer end. This is brought out in actual practice by having one

part of the bridge rigid enough to hold in place that part considered as the cantilever, which is the part jutting out beyond the pier and unsupported at the outer end. An arch type bridge supports itself by the well-known principle of an arch. Any weight placed on the top will be carried to the end by a ring of material known as the arch itself, and which is usually in the form of a vertical circle or ellipse. This form of bridge has the tendency to push apart the piers at each end. A bridge of the simple type acts in the same way as any beam which may be placed on two supports with the weight in the middle. This is the commonest form of bridge in use for short spans.

If a railroad should approach any navigable river, the banks of which are low and would not permit a crossing at any considerable height, it would be found necessary to leave a portion of that bridge so that it may be opened for traffic on the river. This is accomplished by several different forms of lift or swing bridges. One form is similar to a structure swinging around on a pivot. Another form is what is known in the profession as a "bascule" bridge. This type lifts up at one end until when open it will be in an almost vertical position. There is another class that

has come into favor which is formed by sliding a portion of the bridge in question along an oblique direction with respect to the water course. In general these types of bridges can be classed among the most difficult of any form and must be fabricated with the greatest skill and accuracy in order to ensure a perfect fit when closed.

The choice between these six general types of bridge construction is generally made in accordance with the natural features encountered, due attention being paid, of course, to the harmony between the bridge itself and its environs. An important point which governs the choice of type is rigidity of foundation. The arch type makes it necessary that they should be stiff under the varying conditions of traffic. Further, swing or lift bridges should be erected on rigid foundations because of the fact that when closed they must fit tight, and any variation such as would not be noticeable in some classes of bridges would have a serious effect in this case.

Steel bridges are expensive to make, or to use the professional term, to fabricate. This fabrication itself is carried on in the bridge shops. It consists of taking the various shapes rolled by the steel mills and riveting them together to form the various members or parts

that compose a bridge. These parts are then temporarily put together in order to make sure that they will fit in place when the structure is actually being erected. The work in the shops is carried on as far as possible as it is more economical to do that class of work in a shop than out on the field. All sections are, therefore, made as large as can be conveniently transported and erected.

When a bridge is short it is often possible to make all of it in two or three pieces and obtain the greatest economy in erection. All girder bridges are made in this way, even though the span may be as long as one hundred and twenty feet. The erection of the bridge itself after these sections have been brought to the site, usually takes a short time if they are in only a few pieces.

A long bridge, however, may take as much as a year or two to erect, due in part to the fact that there must be some means of support during erection, before the bridge is able to support itself. A common method of erecting a very long bridge is to erect a temporary wooden one that is strong enough to hold the weight of the permanent structure to be placed on top of it. When the final steel work is all built up the wooden parts are taken down and carried away. Two types of bridge, namely,

suspension and cantilever, admit of erection without any wooden supports. These systems are generally in use when the bottom under any structure will not admit of any false work. False work is the professional name for a temporary structure generally of wood which is intended to support a permanent bridge only during its erection. It may happen that the structure in question may be so high above the bottom of a valley that it would be impractical to build the false work to such a great height. One case when its use may be impractical is when the bridge in question would span a stream which must be kept open for water traffic during erection and which may be so deep that the foundation for this false work would be too expensive. It must be remembered in any case that to compare the cost of one bridge with another, they must be of the same length and under the same general conditions.

Unfortunately, steel bridges as a rule lack beauty. Usually a railway bridge crossing a stream in the country can be remembered by its ugliness more than by any other thing. There are a few exceptions to this where a bridge is intended for street traffic near a city. One exception which stands out by itself is the bridge over the Harlem River in New

York City, called the Washington Bridge. This bridge is a steel arch supporting a masonry superstructure.

A reinforced concrete bridge is adaptable to a design of great beauty. The fact that concrete can be made into any shape desired and can afterwards be finished to a smooth white surface, makes it possible to class reinforced concrete bridges among structures having the greatest architectural possibilities. This fact places this kind of material as the best for use in parks, highways, and large estates. Another point which makes the use of reinforced concrete advisable, is the fact that the older the structure is the stronger will be the concrete itself. It is known that concrete will steadily increase in strength for at least five years and will never deteriorate except under the influence of the strongest chemical action. Unfortunately, bridges of reinforced concrete have not been made, up to the present date, of any great length. About four hundred feet is still considered a safe limit for any one span. As the facts governing the action of reinforced concrete gradually become more and more known, this present length of span is almost certain to become increased. The transportation cost of the material, for this kind of material is exception-

ally low, due chiefly to the fact that it can be transported in the most convenient sizes and weights.

The cost of erection, however, is usually high for a long span. A concrete bridge needs a more stable support during erection than one of steel. Further, this support must remain steadily in place during the time which it takes concrete to harden. It must be remembered that when concrete is ready to be placed in position it is in a semi-liquid state, and must, therefore, be enclosed in watertight boxes and left undisturbed until it hardens. This increases the cost of erection and is the only objectionable feature to concrete bridges.

It often happens, especially in railroad work, that a temporary bridge is required which must not only be inexpensive, but must be quickly put in place. For a case of this kind an engineer would invariably suggest one made of wood. The low cost of a wooden bridge makes it attractive to a railroad passing through an untried section of the country, where the earnings would not justify any great outlay in construction. This would apply especially to a railroad leading to a mine which could not be considered permanent.

The value of the speed of erection is best appreciated in cases of emergency. Any per-

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manent structure that has been disabled can most quickly be replaced by timber work. Any railroad which has had its traffic held up by an accident happening to one of its bridges, would readily appreciate the importance of a quick substitution of the previous one, and the consequent resumption of its old schedule. Unfortunately, a bridge of timber can not be considered permanent in the sense that it will last twenty or thirty years. At best its life is much shorter, but can be prolonged by careful painting and by keeping its traffic within well defined limits.

A type of viaduct has been in use for some years which is a combination of a steel bridge and a concrete bridge. It is supported by regular columns made of steel and consists at the top of reinforced concrete beams and flooring. This has been used with great success by railroads going through cities. Its chief advantage is the fact that it gives a solid floor on top and is open underneath. A solid floor on the top of any bridge has the great advantage that railroad tracks or platforms can be arranged anywhere at will and can be rearranged again at any time later. The fact that this viaduct would be supported by steel columns instead of heavy masonry piers, would permit the free use of the street under-

neath. It has an advantage over a structure composed entirely of steel in the fact that it gives a neat appearance due to the concrete work on top and to its symmetry.

It can be seen that there is a considerable variety of materials and types from which to pick a bridge most suited to the purpose and surroundings in any case in question. An engineer in charge of work of this nature would select the type most suitable, taking into consideration the natural features encountered, and the purpose for which the bridge is intended. Through his designs, based on his previous knowledge gained by actual experience, he can economize in the cost and yet insure absolute safety.

It should be of interest to every citizen who pays taxes, to know that he is getting the best bridge possible. A bridge in a park or on a highway is directly used by him, and it is to his own interest to be satisfied that a just balance has been struck by the engineer in charge, between the natural conditions found, the cost, and architectural beauty. It will generally prove expedient to increase the first cost of a bridge to be erected on public property such as in parks or highways in order to obtain architectural beauty. It is obvious that in a beautiful park or street having many

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handsome buildings on it that it would not be advisable to produce an unharmonious effect by the erection of an ugly bridge.

Any one with a knowledge of railroads must know that bridges and viaducts enter strongly into their economical maintenance. Those passing through cities have bridges over the various streets, and those traversing hilly country have bridges over valleys and streams which they may encounter. These structures can be considered the greatest single item which enters in the actual construction of a railroad. It is evident then that they are of the greatest importance to a railroad man on account of their effect on the general economy of any system.

Miscellaneous Steel and Reinforced Concrete Structures

Except Bridges and Viaducts

THIS chapter is intended to cover the various structures made of either structural steel or reinforced concrete that would not cover any great amount of space in pointing out the essential facts which govern their financial value. In any of the following subjects the various kinds of steel used are subject to the choice of the engineer in charge. As a whole they would be considered under the general and broad classification of structural steel.

The first structure or class of structures to come under consideration is steel buildings. It must be borne in mind that the primary objects in using steel in the construction of a building is either to make it fireproof or to increase its height to make the rental space consistent with the cost of the real estate upon which the building is to be erected. The chief value of using steel buildings is the fact of its great supporting strength in proportion to the size of a column used. Formerly eight

stories has been the practical limit of any building made of bricks or stone, because in order to support the great weight at the top the walls at the bottom floor would be so thick as to use up all the space to be rented. There is at present a steel building in New York City with a total height of fifty-one stories, the largest column of which is under three feet square at the bottom.

Any steel building is usually designed by an engineer and an architect working in harmony with each other. The work done by an engineer would include all steel work. That is, the modern skyscraper is the product of the combination of the brains and skill of both professions. In discussing a topic of this kind it would be well to give a general idea of the manner in which an engineer would approach a contract of this kind. He would at first draw up the plans of the steel work while acting in conjunction with an architect. From these designs the cost of the work as completed would be derived and an estimate given of the financial outcome in an undertaking of this kind.

The construction of the steel part of any building is done as far as possible in steel shops. The various columns and girders and beams are riveted together and made ready for put-

ting together in the field. The primary object to be attained would be to do as little work in the field as possible. The use of steel in buildings has become so common that there are several specially rolled shapes which are in use for that purpose only. In almost every case the work of the engineer includes only the design and inspection of the steel frame.

A property owner that would be interested in the erection of a building on his land, should be influenced by several facts. In general it would not pay him to erect a tall building on property of small value. The primary idea of a high building, as has been stated before, is to make up for the high price of real estate in congested districts by increasing the rentable area due to the height of the structure erected. The height to be attained by any building should be established by taking into consideration the price of the real estate to be used; the engineer and architect's estimate of the cost, as well as their estimate of the amount of rentable area. By using the rental rate per square foot in the vicinity an estimate can be made on the probable earnings of the building, taking into account, of course, the fact that a new one can usually command a higher rental than those surrounding it. It is pertinent to add here that steel alone is

not considered fireproof. It must in every case be covered by a thin layer of concrete or some other fireproof material.

It would be of interest to any one considering the erection of a reinforced concrete structure to know why reinforcement is used in concrete. It has been proved by actual experiment that concrete can not be made to withstand any force in tension. By force in tension is meant a tendency to be pulled apart. That is, concrete is able to hold up heavy weights tending to crush it together, but will easily break when pulled apart. It has been found that steel bars imbedded in this material can be made to take up this tension if placed in a correct position in the concrete. Girders and beams of reinforced concrete have in this way been able to give entire satisfaction.

A considerable impetus has been given lately to the construction of reinforced concrete buildings. They have the advantage over other types in that they are absolutely permanent and fireproof, and for small buildings are cheaper than steel work that would reach the same degree of resistance to fire. Similarly to steel buildings the design and superintendence of construction of a reinforced concrete building would be under the charge of an architect and an engineer.

The engineer would have under his consideration its strength and all arrangements that would be influenced by the industrial work for which this building would be intended. He would also have charge of the actual placing of the concrete and of the reinforcement as placed in it. The position which the reinforcement takes in each particular part of a concrete structure is of the greatest importance. Further, it is necessary to have a conscientious inspection while under erection in order to see that the concrete itself is put in the building in the right manner. Proper inspection of any reinforced concrete structure is absolutely essential in obtaining the maximum amount of strength consistent with the material placed in it.

It has become a custom also, due to an engineer's knowledge of the strength and properties of steel, for him to specify the kind of steel used as well as the type of reinforcement system to be put in that building itself. The owner of a structure of this kind would be chiefly interested in the advantages obtained in any class of material used. It has the advantages that have been mentioned before, of being absolutely fireproof and durable.

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The ideal situation for a building of this type is in the country, where land is inexpensive, and which will permit a low building covering a large area. The fact that concrete and the reinforcement used in it can be shipped in convenient sizes makes it possible to save in the transportation charges from the point of shipment. Not only that, but the fact that it is fireproof is of greater advantage in the country than in the city, where modern fire-fighting apparatus is in use. Factories and industrial plants for all purposes, when made of reinforced concrete have given excellent results.

There is a class of reinforced concrete structures which cannot be considered as an engineering property in itself, but would be used in connection with one, and will, therefore, come under this heading. Concrete retaining walls and piers have been in use for a considerable number of years and have given excellent satisfaction. They have the advantage that all concrete structures have, in that the materials used can be transported in any sizes or weights that may be convenient. Furthermore, it has been found less expensive to use concrete in the foundations, and especially so at the point where the foundations actually touch the rock upon which it rests.

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Concrete can be considered at its best in all foundations resting upon any solid material. This advantage is gained chiefly through the fact that it will flow into and fill every crevice in the rough surface upon which it lays, and in doing so, it will distribute evenly over its surface any pressure which has been placed upon it.

Reinforced concrete has been put, within the last few years, to another use, and has proved to be successful. This use is in small reservoirs. It has been found to be advantageous in the floors and walls of a great many reservoirs for both pure water and chemicals used in industrial plants. One strong point in favor of concrete is the fact that very few chemicals can have any effect upon it. Steel has been found to be useless in the presence of acids. Formerly various alloys of copper have been used in connection with chemical plants, but have been found to be very expensive. Reinforced concrete has now taken its place in reservoir construction of this kind and has been found to be more economical and yet give the same results. It would be pertinent to say here, that it has been found by experiment that concrete can be made watertight and even under a considerable water pressure.

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A further use of steel which is subject to the design of an engineer, is roof trusses. Any industrial plant which requires an open floor space of any considerable width or length in which there are not to be any columns, would require roof trusses to support its roof over this usually large space. This roof would have to be designed in accordance with the formulas in use by engineers that take into account wind pressure and snow pressure as well as the weight of the roof itself. The cost of a roof truss would be considerably above the supporting system of a roof as supported by the usual method, but it is often to the advantage of an owner of an industrial plant, and especially so in an exhibition building, to have a clear space of large area which does not contain any columns or other obstructions due to the arrangement of the building.

An important use of steel is in making reservoirs for water systems of various descriptions. Steel has the advantage that it can be rolled into plates and then riveted together. It also can be made to withstand heavy pressures. The edges of these plates after being placed together can be made watertight. A customary method of making a reservoir of steel would be to fabricate it in as large sections as possible and to set up the whole in the field on a

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secure concrete foundation. It is necessary, however, that pure water must be used. Pressures considerably in excess of that conveniently withstood by reinforced concrete can be safely used with steel. In general a high pressure steel reservoir would be cheaper than a high pressure one made of concrete.

Conveying machinery in all its different forms is an important use for structural steel that would come entirely under the attention and supervision of an engineer. An owner of an industrial plant can often reduce his expenses considerably by adding a traveling crane to his equipment. They are made now so that they can be run upon tracks overhead and can lift any reasonable weight and convey it to any spot within the limits in which the crane operates. Practically all of the machine shops which would be apt to handle heavy castings or shafts, sometimes weighing as much as twenty tons, would be equipped with this class of machinery. It must be borne in mind that of machinery. It must be borne in mind that in ery, that the power required for a crane is already on hand. They are made to be run by electricity and operated by a single operator. The owner of any industrial plant that has to handle heavy weights, would find it to his advantage to investigate whether it would pay to install an apparatus of this kind.

Another class of handling device that comes under the attention of an engineer, is conveyor machinery intended to convey materials such as coal and ore within certain limited distances. The various types in use consist of either a belt of some kind running on pulleys, or an endless chain of buckets. In both cases material is dumped into the belt or buckets and is by them carried to the other end of the apparatus and dumped off there. It is well to add that the horizontal conveyor is simply known as a conveyor while an inclined one which carries materials from a lower to a greater height, is known as an elevator. These two can be arranged in such a way that almost any desired direction can be obtained. Any industrial plant that has need of the services of a great many men carrying small weights between any two points, can find it profitable to install a system of this nature. It must be remembered that conveyors have been brought up to such a state of usefulness that they are now made to handle almost any kind of material.

Still another class of conveying machinery which may be properly placed in this article as it comes directly under the charge of an engineer, would be steel towers which are used for unloading boats or cars of their cargo. An

instance of this kind is in common practice by a great many power companies having dock facilities. They erect a steel tower at the dock and install in it machinery which unloads the coal. This same tower is connected by a bridge to the top of the coal bunkers over the boilers and coal is dumped directly into these bunkers without any extra handling whatever. Ore is loaded or unloaded as the case may be by the use of conveying systems much in the same manner as coal. In fact, every mine or ore handling property should have a thoroughly equipped conveying system which would be of the greatest value in reducing maintenance costs.

Telpherage systems or aerial cableways have the advantage that they can carry considerable loads over the top of any obstacles which may be on the ground. They have the further advantage in the fact that they are inexpensive when it is considered that they are often made to carry material three thousand feet or more. An illustration of this kind is where materials have to be carried over a wide stream. They have been found useful in conveying materials such as logs or ore up the sides of mountains too steep for railroad building.

Another condition in which aerial cableways could be used advantageously is where there

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must be some method of transportation in an industrial plant in which the materials carried would have to be carried through streets or yards in which space is valuable. Telpherage systems in this case can be of advantage by transporting its load out of the way of the work going on underneath. In considering any transportation system within the length of reach used by a telpherage system, an engineer would consider the materials to be handled and place his decision according to the conditions found. In general telpherage systems may be considered an inexpensive and advantageous method of transporting materials within a restricted area.

Another use of steel and reinforced concrete has lately come under the attention of the engineering profession and has proved itself to be entirely practical. In many of the larger cities the traffic on the street level has compelled traction companies who wish to make any speed to go below the street level. This makes necessary a strong construction to hold up the roof with its street traffic upon it and keep the sides of these underground railroads from caving in, due to the pressure of the buildings along side. It has been found profitable to use reinforced concrete almost entirely in the roof and sides of these underground railroads.

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There is now being built in Brooklyn and on Lexington Avenue in New York City, two subways which are constructed entirely of reinforced concrete as the result of experience gained by an underground railway in that same city. It was found necessary, however, to use structural steel for stations where the roof would be unsupported for too great a width to allow for the convenient use of reinforced concrete. The design and estimate upon a work of this kind is done solely by engineers and is carried out by them. It is to the interest of every taxpayer and every citizen within reach of one of these systems to know that that work will be carried out successfully.

There are many other uses to which reinforced concrete and structural steel have been put and have proved their worth. They are in isolated cases, however, and will not be considered here. It is sufficient to say, therefore, that each of these engineering properties would be considered as a separate problem by itself and would always be designed with the proper regard to economy and results obtained.

